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A HANDBOOK OF SELECTED BIOLOGICAL REFERENCES ON WATER POLLUTION CONTROL SEWAGE TREATMENT, WATER TREATMENT

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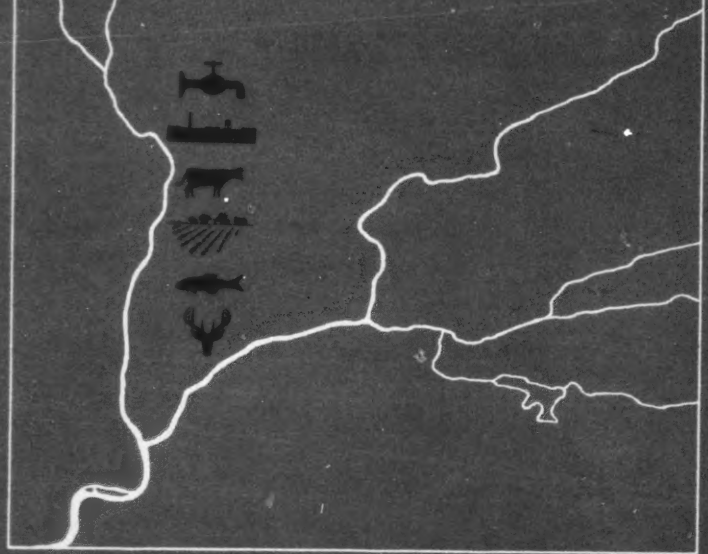
on

Water Pollution Control
Sewage Treatment
Water Treatment



U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE - Public Health Service

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Handbook of

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Water Treatment

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Bureau of State Services
Water Supply and Water Pollution Control Program
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Foreword

The great demand for the original Handbook of Selected Biological References on Water Pollution Control, Sewage Treatment, Water Treatment, which was published in 1953, as Public Health Service Publication No. 214, has prompted this *Revision*. The numerous biological publications, relating to various aspects of water pollution, waste treatment, and water supply, that have appeared in the technical literature over the last several years, emphasize the urgency of bringing the 1953 handbook up to date with this publication.

The author of this *Revision*, who compiled and organized the references in the original 1953 handbook, wishes to continue acknowledgment to those who gave freely of their time in assisting in various ways in preparation of the original work, namely: Carl E. Schwob, Chief, and A. F. Bartsch, Biologist, Division of Water Pollution Control, (then) Washington, D. C., W. W. Towne, Officer in Charge, and J. W. Wiseman and C. H. Hull of the Ohio and Tennessee Drainage Basins Office, Division of Water Pollution Control, Cincinnati, Ohio, all of the Public Health Service, and Dr. G. W. Prescott, Department of Botany, Michigan State College, East Lansing, Michigan, for drafting the original illustrations of toxic freshwater algae.

Those who have given of their support in the formulation of this revision and who have participated in various ways in furthering its completion are: Bernard B. Berger, Chief, and A. F. Bartsch, Biologist, Water Supply and Water Pollution Program, and W. W. Towne, Chief, Water Pollution Control, Water Supply and Water Pollution Program, Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio, and Paul W. Reed, Chief, Water Pollution Control, and John T. Barnhill, Chief, Program Aids and Reports Section, Water Supply and Water Pollution Control Program, Washington, D. C., all of the Public Health Service.

Introduction

These biological bibliographies may be found useful as pertinent references for those working in water pollution control, sewage treatment, and water treatment.

The bibliographies are by no means complete. The references in them were selected largely for their availability and potential usefulness to those not trained primarily in biology. A complete list of references on the biological phases of water pollution, water treatment, and sewage and industrial waste treatment, would be too voluminous and of slight use to the sanitary engineer, chemist, or bacteriologist. Therefore, these brief bibliographies can serve those in water pollution control programs, sewage treatment, and water treatment in unfolding information that may be basic to a good understanding of certain biological problems that could arise in the course of professional work. Marine waters are not considered.

The selected biological references applicable to water pollution control programs might be most effectively applied if a general understanding of ecology (the relationship of organisms to each other and to environment in which they live) is gained. A book, *Limnology* by P. S. Welch, McGraw-Hill Book Co., New York, 471 pages, will introduce one adequately to the ecology of various bodies and systems of inland waters. Inseparable from a general understanding of ecology in water pollution control programs is an awareness of the varied biological samplers that are available. Welch has published a second book, *Limnological Methods*, The Blakiston Co., Philadelphia, Pa., 381 pages, which adequately and critically analyzes biological equipment that can be employed effectively in water pollution control work.

The selected biological references applicable to sewage and industrial waste treatment, in general, include publications that deal directly with specific organisms, rather than those that are of a chemical-biological nature. They generally omit mention of specific organisms. References in the fields of bacteriology and parasitology, two highly specialized branches of biology, are generally omitted. A few bacteriological papers dealing with *Sphaerotilus* and zoogleal bacteria that often are associated basically with many other organisms in sewage treatment are included. Certain references to parasites are listed merely to make one aware of parasitic diseases as they may or may not be associated with sewage. The bibliography on insect control includes references directly applicable to filter flies and mosquitoes associated with sewage treatment installa-

tions. No attempt has been made to list numerous references that deal with general fly and mosquito control.

Several illustrations of animals that are associated with concentrations of organic wastes such as domestic sewage are included. These illustrations may prove of value to demonstrate to educational and civic groups and others visiting sewage treatment plants that organisms, in addition to bacteria, are intimately associated with treatment. It is easier to visualize through illustration that sewage treatment is to a great extent a biological process. One can affirm that organism associations illustrated here may be found in large numbers in sections of streams that are badly polluted by domestic sewage, where fish are absent and where foul odors are given off. Thus, a positive point can be made that the illustrated organisms should be concentrated in man-constructed sewage treatment plants, rather than allowing streams to shoulder the sewage treatment task. As a contrast, illustrations of "clean water" associations of certain animals are shown. These are not found in sewage treatment plants, nor do they live typically and abundantly in stream areas or in lake areas that are heavily polluted by domestic sewage. Nominally this organism association may be found living with desirable fish species in recreational water.

A poster-plate demonstrates how water quality can affect aquatic life by showing the correlation between certain chemical and physical conditions and organisms which are present in polluted waters, having a restricted use, and in clean waters of value for multiple usage. Radioactive wastes are portrayed in a plate illustrating various pathways such wastes may take in passing from water into man.

The selected biological references applicable to water treatment are organized into bibliographies that will refer the reader to organism problems that have been associated with specific steps in the water treatment process. Occasionally a reference is repeated under various bibliographies if it contains information that may be applied specifically to more than one phase of water treatment. Certain references that may deal with more than one aspect of water treatment are cited only once, if the preponderance of information contained therein seems to be most applicable to a specific aspect.

Although there are numerous good books on water treatment, the following titles are selected for special mention of their biological contents:

(1) *The Quest for Pure Water*, by M. N. Baker, presents an outstanding account of the historical development of water purification. References to organisms in water supply are made throughout the text. The chapter on "Algae Troubles and Their Conquest" is of especial interest.

(2) The book, *Water Quality and Treatment*, compiled by a committee of the American Water Works Association, contains two

chapters that present pertinent information on biological aspects of water treatment. The chapter, "Organisms in Water," includes a number of fine photomicrographs that should prove most helpful as an aid to the recognition of certain kinds of algae, protozoa, rotifers, coelenterates, and crustacea. The chapter, "Control of Impounding Reservoirs," presents valuable information on preparation of reservoir sites in relation to organism production, control of algae and other organisms, and fish life in reservoirs.

(3) C. H. Cox's book, *Laboratory Control of Water Purification*, contains a well-written, illustrated chapter on "Micro-organisms, Their Identification and Control."

(4) The British book, *Manual of British Water Supply Practice*, presents a most thoroughly compiled chapter, "The Biological Examination of Water." This chapter presents in an informative, condensed manner the following biological aspects of water treatment:

a. Importance of and purpose for biological examination of water.
b. Classification and identification of microorganisms.
c. Collection of samples for microscopical examination.
d. Evaluation of biological content of water.
e. Expression of results of biological examination.
f. Fundamental factors governing the growth of microorganisms in rivers and reservoirs.
g. Liability of water supplies to algal troubles.
h. Biology of filtration.
i. Prevention and control of plant and animal growths in water works.
j. Tastes and odors caused by algae and other aquatic growths.
k. Higher aquatic plants in water works.
l. Fish life in water works.

(5) Finally, the *Microscopy of Drinking Water* by Whipple, Fair, and Whipple, which has served so many working with various aspects of potable water supplies, is recommended as a "must reference."

One of the most pressing problems for the water treatment plant operator is the control of microorganisms or plankton that cause tastes and odors and also necessitate the frequent backwashing of filters at certain times. Basic to any attempt, other than a random one, to control such organisms, is the collection of data which will help one to associate increasing numbers of organisms with potential problems that may arise at a water treatment installation. If data in simple numerical counts and kinds of organisms are kept over a period of time, it may be possible to forecast potential trouble periods for a given water when certain organisms are increasing, and to kill such organisms in an impounding reservoir before serious tastes and odors are produced and filters are badly clogged.

The late C. P. Hoover, for example, at the Columbus, Ohio, Water Treatment Plant, successfully made use of plankton data to control algae on the Griggs Reservoir before they descended on him to cause trouble in the plant, (Taft, C. E., 1945, 1949, *General References Bibliography*). A plankton record sheet that appeared in the *Journal of the American Water Works Association* is reprinted here, with the belief that it may be useful to water treatment plant operators as a guide in setting up basic data sheets that may be used in plankton control programs (Ingram, W. M., and C. M. Palmer, 1952, *General References Bibliography*).

Of recent papers that discuss algae problems at water treatment installations, one that has been published with outstanding colored illustrations, with [Mr.] Harry Walters of the University of Michigan as the delineator, should prove very valuable in the water works field (Palmer and Tarzwell, 1955, *General References Bibliography*).

Bacteria, except for the Actinomycetes, generally are not considered in this section. The Actinomycetes are noted here since some believe that certain tastes and odors that have been attributed to algae should in reality be assigned to this group of bacteria (Silvey, 1950, *Actinomycetes Bibliography*).

The section on organism identification includes only general references, since the correct usage of highly technical identification literature is usually limited to specialists. In dealing with organism identification—a necessary, difficult, and integral part of biology—colleges and universities can often lend assistance in obtaining the correct names of animals and plants

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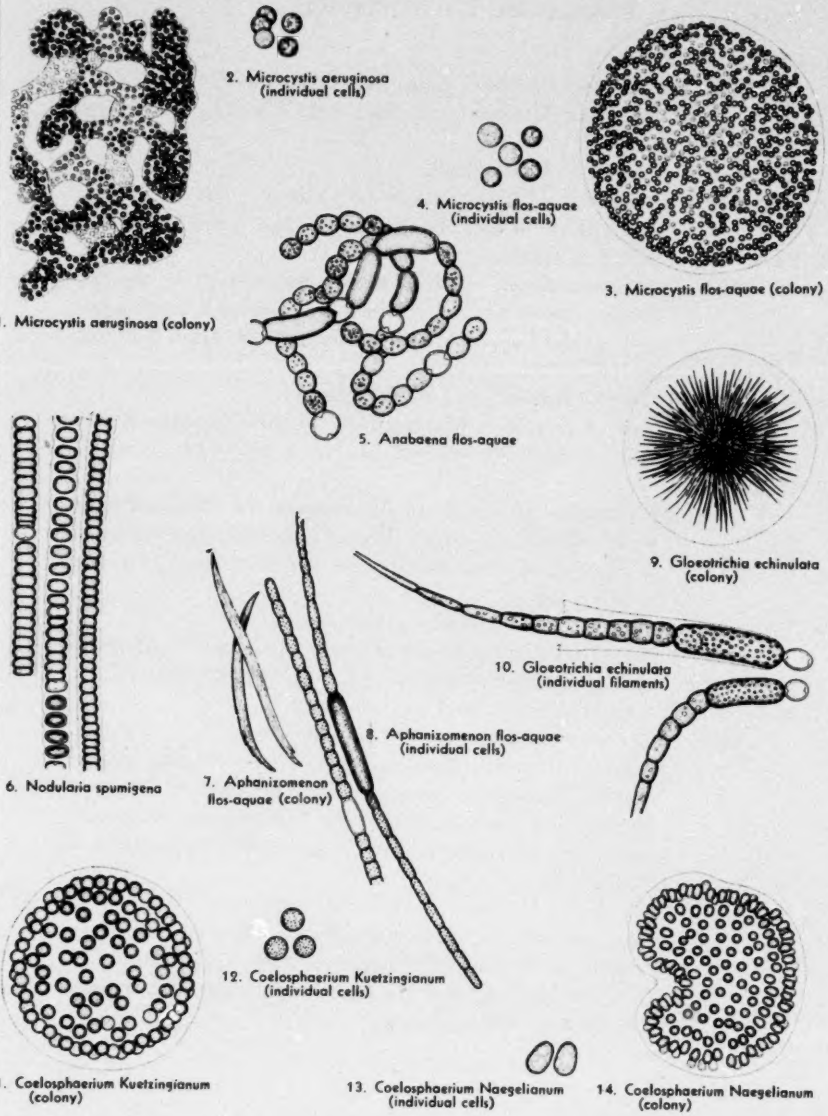
6. Plate I—Description of Toxic Algae Illustrations

Figures:

1. *Microcystis aeruginosa* Kütz. A colony of cells showing cathrate and perforate gelatinous sheath inclosing numerous, irregularly arranged individuals.
2. *Microcystis aeruginosa* Kütz. Individual cells showing the false vacuoles which refract the light and give the colony a "blackish" appearance when viewed microscopically.
3. *Microcystis flos-aquae* (Wittr.) Kirch. A globular colony.
4. *Microcystis flos-aquae* (Wittr.) Kirch. Individual cells.
5. *Anabaena flos-aquae* (Lyngb.) Breb. A tangled filament showing the sausage-like spores.
6. *Nodularia spumigena* Mert. Filaments of short, compressed cells.
7. *Aphanizomenon flos-aquae* (L.) Ralfs. Diagram of flake-like colonies as they appear microscopically.
8. *Aphanizomenon flos-aquae* (L.) Ralfs. Individual trichomes, showing (right) the enlarged spore and (left) the heterocyst characteristically located near the median region of the plant.
9. *Gloeotrichia echinulata* (J. E. Smith) P. Richter. Diagram of colony in which filaments radiate from a common center, forming tapioca-like bodies suspended in the water.
10. *Gloeotrichia echinulata* (J. E. Smith) P. Richter. Individual plants showing basal heterocyst and spore, from which the vegative cells taper to a hair-like extremity.
11. *Coelosphaerium Kuetzingianum* Naeg. Colony.
12. *Coelosphaerium Kuetzingianum* Naeg. A few cells showing homogeneously granular content.
13. *Coelosphaerium Naegelianum* Unger. Few cells showing false vacuoles which refract the light and give the colony a brownish or purplish color when viewed microscopically.
14. *Coelosphaerium Naegelianum* Unger. Colony in which radiating fibrils are often visible; the cells crowed at the periphery of the colonial sheath.


1. Microcystis aeruginosa (colony)
2. Microcystis aeruginosa (individual cells)
3. Microcystis flos-aquae (colony)
4. Microcystis flos-aquae (individual cells)
5. Anabaena flos-aquae
6. Nodularia spumigena
7. Aphanizomenon flos-aquae (colony)
8. Aphanizomenon flos-aquae (individual cells)
9. Gloeotrichia echinulata (colony)
10. Gloeotrichia echinulata (individual filaments)
11. Coelosphaerium Kuetzingianum (colony)
12. Coelosphaerium Kuetzingianum (individual cells)
13. Coelosphaerium Naegelianum (individual cells)
14. Coelosphaerium Naegelianum (colony)

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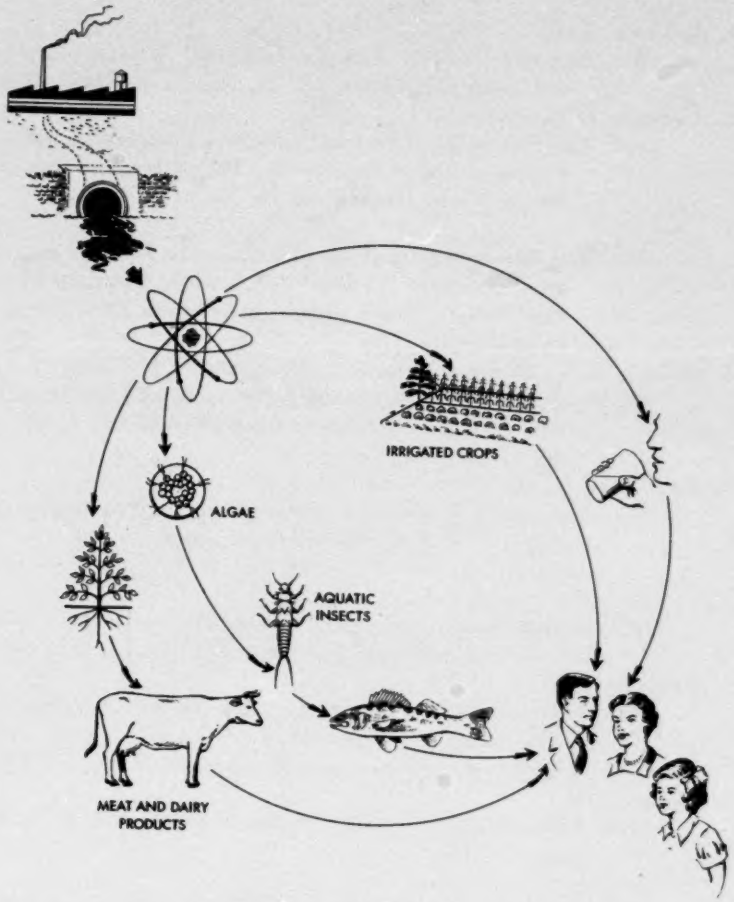
8. Plate II—Radioactive Wastes From Water to Man



(From: Tsivoglou, E. C., E. D. Harward, and W. M. Ingram. 1957. *Stream Surveys for Radioactive Waste Control*, American Society of Mechanical Engineers, second Nuclear Engineering and Science Conference, Philadelphia, Pa., March 11–14, pp. 1–12.)

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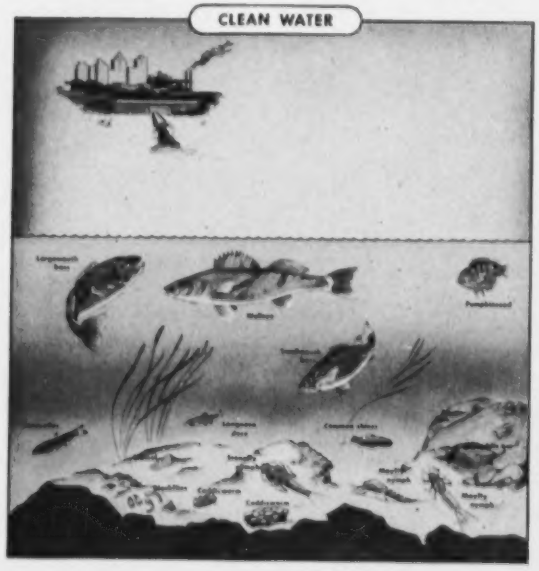
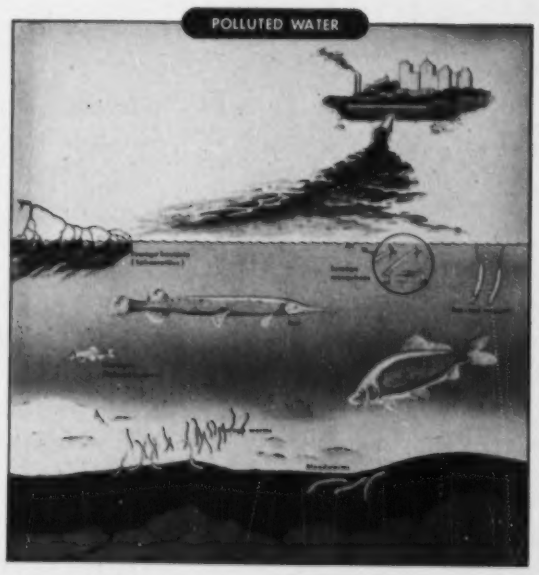
13. Plate III. Water Quality Affects Aquatic Life



CHEMICAL PHYSICAL CONDITIONS	AQUATIC LIFE
Dissolved oxygen high	Sport fish numerous
Toxic effects absent	Many minnows
Favorable pH	Clean water invertebrates
Organic pollution low	Clean water algae
No sludge deposits	Sewage bacteria few

PERMITS MULTIPLE WATER USES



AQUATIC LIFE	CHEMICAL PHYSICAL CONDITIONS
Sport fish absent	Dissolved oxygen low
Few minnows	Chemicals may be present
Polluted water invertebrates	Unfavorable pH
Polluted water algae	Organic pollution high
Sewage bacteria abundant	Sludge deposits

RESTRICTS WATER USES

Fishes shown in relative scale; all other organisms not shown in relative scale

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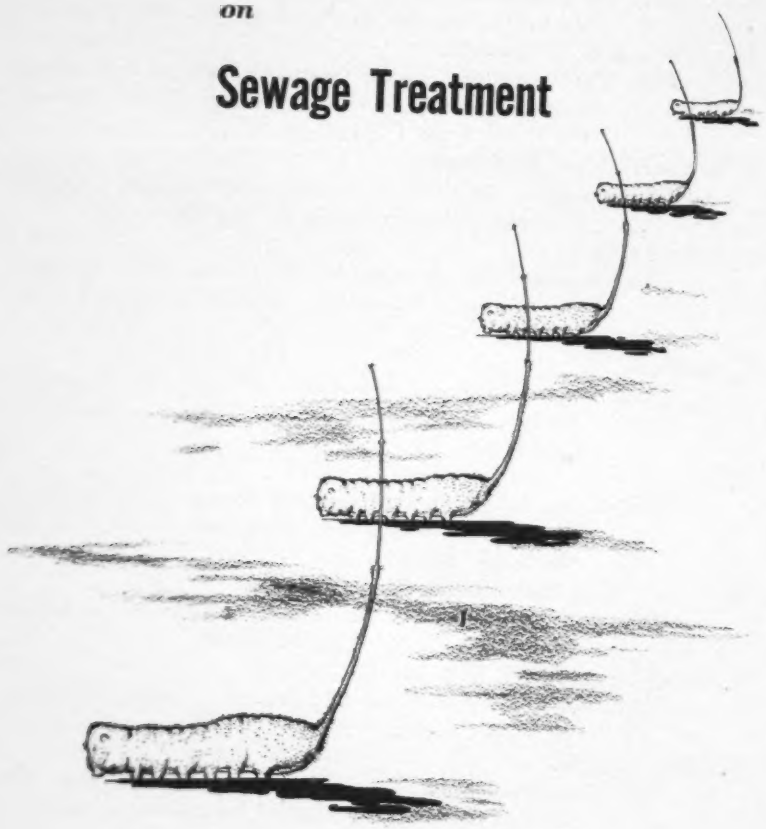
SELECTED BIOLOGICAL REFERENCES

on

Sewage Treatment



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12. Plate IV—"Clean Water" Organism Association*

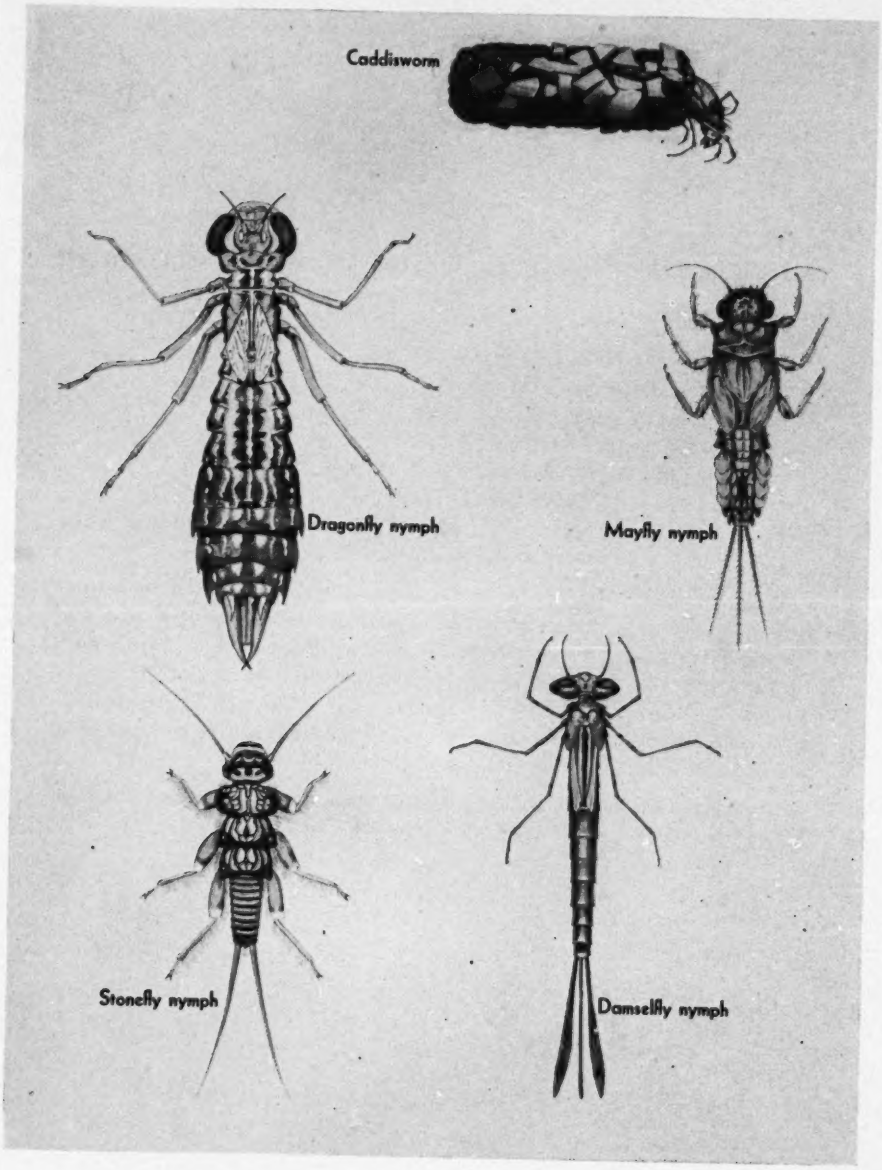
Figures:

1. Caddisworm (x4)
2. Dragonfly nymph (x2)
3. Mayfly nymph (x5)
4. Stonefly nymph (x2)
5. Damselfly nymph (x2)

The organism association of Plate IV is typical of that found in "clean water." It is not found in sewage treatment plants, nor do these animals live abundantly in lakes or in stream areas that are heavily polluted by domestic sewage. Nominally, this association is found living with desirable fish in water that is recreational.

*Are redrawn and in part taken from: P. W. Claassen, 1932, The Biology of Sewage Treatment, *Sewage Works Journal*, vol. 4, No. 1, pp. 165–172.

12. Plate IV—"Clean Water" Organism Association



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13. Plate V—"Polluted Water" Organism Association*

Figures:

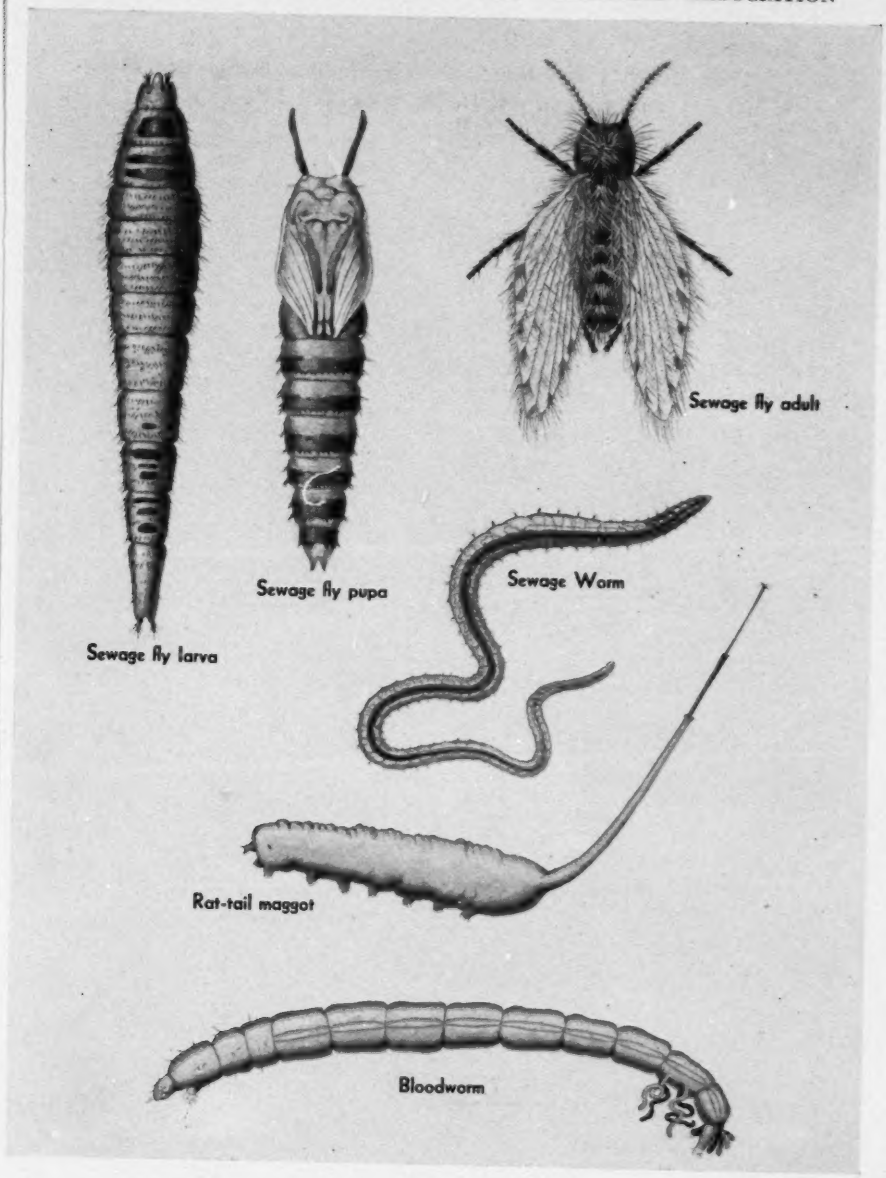
1. Sewage fly larva (*Psychoda*) (x13)
2. Sewage fly pupa (x13)
3. Sewage fly adult (x11)
4. Sewage worm (Tubificidae) (x5)
5. Rat-tail maggot (*Eristalis*) (x2)
6. Bloodworm (Chironomidae) (x4)

(Only certain species such as *Chironomus plumosus* are pollutional, while others prefer non-polluted water)

Huge numbers of organisms in this association are found in the supernatant fluid over a sludge drying beds, with the larvae and pupae of the "Sewage Mosquito," *Culex pipiens*, that is not illustrated. Certain ones of them are also found in the supernatant fluid of Imhoff tanks, in activated sludge and in trickling filters. Excepting the "Sewage fly," *Psychoda*, this animal association is well represented in stream areas that are heavily polluted by domestic sewage.

*Are redrawn and in part taken from: P. W. Claassen, 1932, The Biology of Sewage Treatment, *Sewage Works Journal*, vol. 4, No. 1, pp. 165–172.

13.—Plate V—"Polluted Water" Organism Association



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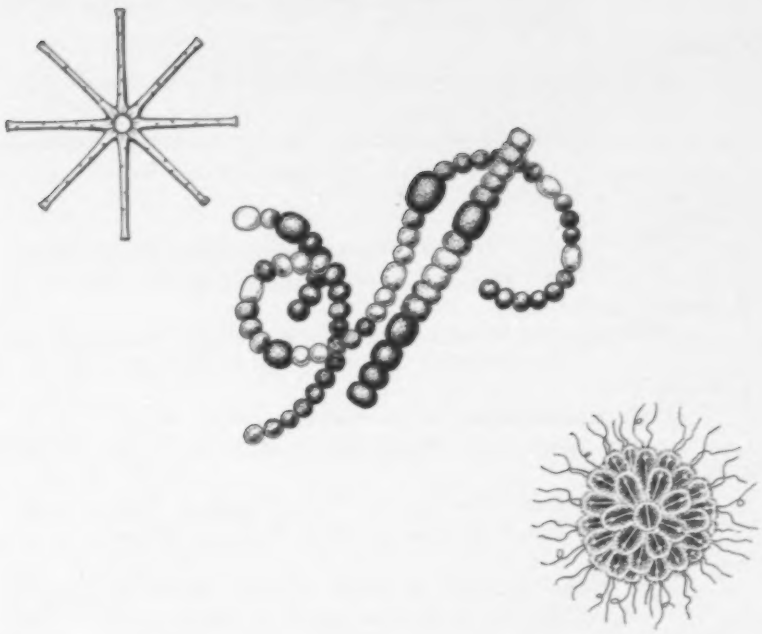

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17. Plate VI—Plankton Record Sheet

SHEET NO.____

_____ WATER TREATMENT PLANT

PLANKTON RECORD

STA.____ DEPTH OF SAMPLE____ DATE COLLECTED____ HR.____

ORGANISMS	FIELDS EXAMINED I	II	III	IV	V	VI	VII	VIII	IX	X	NO. ORGANISMS IN 10 FIELDS	NO. ORGANISMS PER ML	NO. ORGANISMS PER GAL.
TOTAL COUNT													
DIFFERENTIAL COUNT													

COLLECTOR'S INFORMATION	EXAMINER'S INFORMATION
1. COLLECTED BY:_____	7. ANALYZED BY:_____
2. WATER TEMPERATURE:_____	DATE:_____ 19____
3. WEATHER: (CLEAR ETC.)_____	8. METHOD OF CONCENTRATION:_____
4. VOL. OF SAMPLE COLLECTED:_____	9. VOLUME OF SAMPLE & CONCENTRATE
5. PRESERVATIVE (KIND & ANT.):_____	a._____ ML OF SAMPLE FILTERED
6. CONDITION OF WATER & PLANT SYSTEM.____	b._____ ML OF FINAL CONCENTRATE
a. ATTACHED ALGAL GROWTH IN RESERVOIR:____	10. CONVERSION FACTORS TO:
b. SURFACE SCUM:_____	a. NO. ORGANISMS/ML_____
c. DEAD FISH:_____	b. NO. ORGANISMS/GAL_____
d. TURBIDITY, (RAW) WATER:_____	11. SIGNIFICANCE OF ORGANISMS FOUND:
e. ODOR IN RAW WATER:_____	_____
f. CLOGGING OF FILTERS:_____	12. TREATMENT RECOMMENDED:
g. ODOR (& TASTE) IN FINISHED WATER____	_____
h. OTHER CONDITIONS:_____	_____

From WM. Ingram and C.M. Palmer, "Simplified Procedures for Collecting, Examining and Recording Plankton in Water", J.A.W.W.A., 44: 617-624

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